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WATER RESOURCES STUDY-CENTRAL OKLAHOMA
NAVIGATION PROJECT DEEP FORK RIVER BASIN
OKLAHOMA

Public Health Service
Dallas, Texas

March 1964

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**WATER RESOURCES STUDY
CENTRAL OKLAHOMA NAVIGATION PROJECT
DEEP FORK RIVER BASIN
OKLAHOMA**

**Study of Potential Needs and Value of
Water Storage for Municipal, Industrial,
and Quality Control Purposes**

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**U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas**

WATER RESOURCES STUDY
CENTRAL OKLAHOMA NAVIGATION PROJECT
DEEP FORK RIVER BASIN
OKLAHOMA

Prepared for
DEPARTMENT OF THE ARMY
U.S. Army Engineer District
Tulsa, Oklahoma

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas

MARCH 1964

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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
REGIONAL OFFICE

PUBLIC HEALTH SERVICE

1114 Commerce Street
Dallas, Texas 75202

May 7, 1964

Your reference:
SWTWR

District Engineer
U.S. Army Engineer District, Tulsa
P. O. Box 61
Tulsa, Oklahoma 74102

Dear Sir:

In accordance with our recent discussion regarding our report entitled "Water Resources Study, Central Oklahoma Navigation Project, Deep Fork River Basin, Oklahoma," dated March 1964, the following modifications should be incorporated in that report.

1. Conclusion number 7 (Page II-3) should be revised to read as follows:

"Based upon the proposed water quality control plan, the minimum value (1975 worth) of the benefits attributable to water quality control by regulation of Deep Fork River is estimated as \$449,000 annually. This value is established on the basis of the cost of the most likely alternative to storage in a multipurpose project, in this case, a single-purpose reservoir capable of yielding flow regulation for quality control needed to preserve stream quality at a suitable level in the absence of navigation use of the stream. Storage, to yield an annual average of 20 mgd, 95 of every 100 years, at the Arcadia Reservoir site meets these criteria for water quality control by flow regulation."

2. The last paragraph on Page VII-3 should be revised to state:

"According to the findings presented in table VII-1, the benefits of storage in the proposed multipurpose projects will have a minimum value equal to the cost of a single-purpose project capable of yielding 22,300 acre-feet annually 95 percent of the time. A single-purpose reservoir at the Arcadia site (which is ideally suited for this use in terms

of location) would have an estimated first cost of \$12,391,000, including interest during the 2 years required to construct it. 14/"

3. Page VII-4 should be changed to read:

"Annual charges are estimated as follows:

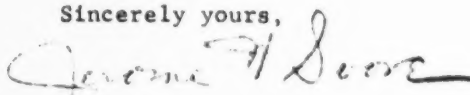
Principal and interest--100 years @ 3%	\$392,100
Maintenance, operation, and major replacements	<u>58,900</u>
Total	\$449,000 <u>14/</u>

Based on the water supply and water quality control plan outlined in table VI-2, there does not appear to be a need for or value of storage for municipal and industrial water supply purposes, while the annual value of the benefits attributable to water quality control by flow regulation is estimated to be \$449,000."

4. Reference 14 on page VIII-2 should be:

"Corps of Engineers letter dated April 22, 1964, and telephone conversation with Tulsa District Office on May 5, 1964."

Sincerely yours,



Jerome H. Svore
Regional Program Director
Water Supply & Pollution Control

I. INTRODUCTION

Authority

In a letter dated March 22, 1963, the Corps of Engineers, Tulsa District, requested the Public Health Service to "make such investigations as may be required to determine the needs for and value of water quality control in the navigation canal under consideration, the quality of flows in Deep Fork River, and the need for and value of additional municipal and industrial water in the Deep Fork area." 1/

This study has been made in accordance with (1) the Memorandum of Agreement dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare, relative to Title III, Public Law 85-500 as amended by Public Law 87-88, and (2) the Federal Water Pollution Control Act (Public Law 84-660) as amended by Public Law 87-88.

Purpose and Scope

The purpose of this study was to determine water requirements to the years 2025 and 2075 for municipal, industrial, and water quality control purposes in the Deep Fork River basin, located in east-central Oklahoma, and how these needs may be met. An estimate of the average annual value of benefits which could be ascribed to storage allocated to these purposes is evolved from projected economic developments and anticipated needs for water supply and stream quality preservation.

Acknowledgments

The assistance and cooperation of agencies and individuals who provided data for this report are gratefully acknowledged. These include: Oklahoma Water Resources Board; Oklahoma State Department of Health, Division of Sanitary Engineering; and city officials and members of Chambers of Commerce of Bristow, Okmulgee, Henryetta, Oklahoma City, and Okemah, Oklahoma; as well as those representatives of industry in the Deep Fork River basin who supplied information relating to existing water requirements.

II. SUMMARY AND CONCLUSIONS

Summary

1. The Central Oklahoma Navigation Project is a Corps of Engineers proposal located in the Deep Fork River basin of east-central Oklahoma and includes two multipurpose reservoirs on headwater tributaries to the Deep Fork River. (See location map.)
2. Water to be impounded at the proposed sites is of suitable quality for general municipal and industrial uses.
3. Much of the study area is open prairie with an annual mean temperature of 62° F and an annual rainfall of about 34 inches.
4. Major industries in the study area are manufacturing, mining, and agriculture. Petroleum refining and glass products manufacturing are the most significant water-using industries.
5. Okmulgee, Henryetta, and Bristow are the principal communities in the study area.
6. Employment in 1960 totaled 23,500 out of a total population of 77,600. Where urban populations represented only one-fifth of the area total in 1920, it was almost 50 percent of the total in 1960.
7. The study area has experienced marked changes in its agricultural industry--a substantial loss in the number engaged in agricultural pursuits and a noticeable shift from crop to livestock production.
8. Rural population in the study area has declined to a marked degree since 1930; urban population declined also, but to a much lesser degree.

Conclusions

1. Population of the study area to be served by municipal water systems is expected to reach 72,000 by the year 2025. Total projected municipal water needed to serve that population is 10.8 million gallons daily (mgd)--12,100 acre-feet annually.

2. Industrial water requirements will increase principally as a result of use in clay, glass, and stone products manufacture; chemical and allied products production; food and kindred products processing; primary metals products manufacturing; and other industrial activities expected to locate in the study area. Total industrial water needed for the year 2025 is estimated to be 11.2 mgd--12,500 acre-feet annually.
3. Changes in flow characteristics caused by alterations of the stream channel for navigation use with the expected reduction in self-purification resulting from these changes in flow characteristics is recognized in the releases for water quality control through flow regulation, shown in the plan below.
4. A supply versus balance for serving projected 2025 and 2075 needs for municipal, industrial, and water quality control purposes are summarized below.

Use	Requirements		Supply		
	Acre-ft. Annually	Avg. mgd		Expected Acre-ft. Annually	Use Avg. mgd
2025. . . .			2025. . . .		
Municipal	12,100	10.8	Existing & Firmly Committed Sources	13,400	12
Industrial	12,500	11.2	Deep Fork--downstream from Arcadia	11,200	10
	24,600	22.0		24,600	22
Quality Control	41,000	36.8	Controlled Releases downstream from Arcadia & Wellston	41,400	37
2075. . . .			2075. . . .		
			Ground Water and Sources of Supply other than Deep Fork	13,400	12
Municipal and Industrial	33,500	30.0	Deep Fork	22,300	20
				35,700	32
Quality Control	41,000	36.8	Controlled Releases downstream from Arcadia & Wellston	41,400	37

5. Releases from the proposed Arcadia Reservoir will provide for water quality control by regulating stream-flow. Based upon current southwestern criteria of 90 percent removal of biochemical oxygen demand (BOD), up to 22,300 acre-feet annually (20 mgd) of adequately treated wastes from the Oklahoma City area can be released to the Deep Fork downstream from this reservoir without unduly degrading water quality for legitimate uses. If improved waste treatment practices result in higher BOD removals, adequately treated waste releases can be increased.
6. Benefits can be attributed to water quality control, resulting from the avoidance of adverse effects which would accrue in the absence of flow regulation through use of storage in these projects. These benefits include: reduced cost of obtaining municipal and industrial water supply; enhancement of recreational opportunities along the main stem; improvement of fish and other aquatic biology; and preservation of the esthetics of enjoyment of flowing surface waters.
7. Based upon the proposed water quality control plan, the minimum value (1975 worth) of the benefits attributable to water quality control by regulation of Deep Fork River is estimated as \$485,900 annually. This value is established on the basis of the cost of the most likely alternative to storage in a multipurpose project, in this case, a single-purpose reservoir capable of yielding flow regulation for quality control needed to preserve stream quality at a suitable level in the absence of navigation use of the stream. Storage, to yield an annual average of 20 mgd, 95 of every 100 years, at the Arcadia Reservoir site meets these criteria for water quality control by flow regulation.

III. DESCRIPTION OF PROJECT

Preliminary studies by the Tulsa District office, Corps of Engineers, for extension of navigation into central Oklahoma, favor a route extending from an arm of the authorized Short Mountain Reservoir (on Arkansas River) along Dirty Creek into Eufaula Reservoir (as shown on the location map at the back of this report, figure III-1), then westward up the Deep Fork River to the vicinity of Oklahoma City. 1-2/

Current estimates by the Corps of Engineers indicate that two reservoir sites (shown on figure III-1) may justify development for flood control purposes, and thus should be considered for multipurpose development. Pertinent data for each of these sites is presented in table III-1.

Table III-1

Description of Proposed Corps of Engineers Reservoirs

<u>Reservoir</u>	<u>Stream</u>	<u>Location (Riv.mi.)</u>	<u>Drainage Area (Sq.mi.)</u>	<u>Yield From Storage</u>		<u>Drought Recur- rence Interval</u>
				<u>Acre-ft. Annually</u>	<u>Avg. (mgd)</u>	
Arcadia	Deep Fork River	213.6	105	25,700	23	50
				33,500	30	20
Wellston	Captain Creek	4.2	49	21,200	19	50
				26,900	24	20

Source: Corps of Engineers 3/

Streamflow

Since flow in the Deep Fork River will be regulated to facilitate navigation, data were provided indicating expected regulated flow conditions in Deep Fork River. Table III-2 compares unregulated and modified flows in Deep Fork River.

Water Quality

Data pertaining to water quality in the main stem of Deep Fork River and various tributary streams to be affected by the proposed navigation project are summarized in table III-3. Indications are that, although the surface waters of various Deep Fork River tributaries contain more hardness than is desirable, it will be suitable with proper treatment for most municipal and industrial water supply uses.

Table III-2

Comparison of Natural and Modified Flows
of the Deep Fork River

Month	Regulated		Natural Flow <u>a/</u> (cfs)						
	Flow <u>b/</u> (cfs)	Velocity <u>c/</u> (ft./sec.)	Reach No. <u>d/</u>						
			1	2	3	4	5	6	7
Jan.	44	0.04	11	10	10	8	6	4	3
Feb.	57	0.04	20	19	18	14	11	7	5
Mar.	66	0.04	23	22	21	16	12	8	6
Apr.	77	0.04	55	52	50	40	29	19	14
May	106	0.06	300	285	270	215	160	110	75
June	115	0.06	110	105	100	80	58	37	27
July	152	0.08	50	47	45	36	27	17	12
Aug.	118	0.07	12	11	11	9	6	4	3
Sept.	104	0.06	7	2	2	1	1	1	0
Oct.	91	0.05	1	1	1	1	1	0	0
Nov.	66	0.04	4	4	4	3	2	1	1
Dec.	57	0.04	3	3	3	2	2	1	1

a/ The natural flows are those that are expected to be equaled or exceeded 95 percent of the time.

b/ At the confluence of Captain Creek. Flows are regulated releases from Arcadia and Wellston Reservoirs (average 57 cfs) plus 31 cfs adequately treated wastes from Oklahoma City area.

c/ Applies to cut channel section.

d/ Reaches are as follows:

<u>Reach No.</u>	<u>Description</u>
1	Eufaula Res. to Lock and Dam No. 22
2	Lock and Dam No. 22 to Lock and Dam No. 23
3	Lock and Dam No. 23 to Lock and Dam No. 24
4	Lock and Dam No. 24 to Lock and Dam No. 25
5	Lock and Dam No. 25 to Lock and Dam No. 26
6	Lock and Dam No. 26 to Lock and Dam No. 27
7	Upstream to Lock and Dam No. 27

Source: Corps of Engineers 2/

Table III-3

Water Quality Characteristics
Deep Fork River Basin, Oklahoma
 (Chemical Analysis in mg/l)

<u>Stream</u>	<u>Sampling Point</u>	<u>Date(s)</u>	<u>Type of Samples</u>	<u>SD₄</u>	<u>Cl</u>	<u>DS</u>	<u>Total Hardness*</u>	<u>HCO₃</u>
Deep Fork River	Near Dewar (mouth)	1948-49	Wgt. Avg.	12	84	243	94	72
Bell Cow Creek	Near Chandler	7-13-53	Grab (typical summer)	--	16	--	75	91
		12-24-50	Grab (typical winter)	12	18	404	380	439
Bear Creek	Near Fallis	4-19-50	Grab (typical)	--	15	400	276	385
Captain Creek	Near Wellston	4-11-55	Grab (typical)	--	30	300	194	234
Dry Creek	Near Kendrick	9-30-55	Grab	--	8.2	66	40	42
Quapaw Creek	Near Meeker	4-28-55	Grab (typical)	--	38	310	160	216

*as CaCO₃.

Source: Geological Survey 4/

IV. DESCRIPTION OF THE STUDY AREA

The Deep Fork River basin, in which the proposed navigation project is located, extends in a westerly direction from Eufaula Reservoir on the east to headwaters in Oklahoma County in the eastern part of central Oklahoma. The study area (shown in figure III-1), consisting of Lincoln, Okfuskee, Okmulgee, and that part of Creek County lying within the Deep Fork River basin, is situated in the Sandstone Hills region. Much of the country is open prairie, but other parts are occupied by a belt of scrub oak forests. The land tends to rise to the west in successive escarpments. 5/

Local interest in Deep Fork River has been evident in the past. A number of years ago, organized drainage and flood control districts in Oklahoma and Lincoln Counties, participated in channel improvement projects for the main stem of the Deep Fork River.

Mean temperature in the study area ranges from 40° F in January to 83° F in July for an annual mean of 62° F. Mean annual rainfall is about 34 inches with approximately 22 inches falling during the 6-month period April through September. 5/

Okmulgee, Henryetta, and Bristow are the principal communities within the study area. Major economic endeavors are agriculture, mining, and manufacturing industries. Petroleum refining and glass products manufacturing are the most significant water-using manufacturing activities.

V. THE ECONOMY

Present

Employment

Employment data shown in table V-1 reflect the major changes in composition of the labor force between 1940 and 1960. Petroleum refining, zinc smelting, and manufacture of glass products accounted for approximately 75 percent of manufacturing employment in 1960.

Table V-1

Study Area Employment--1940, 1950, and 1960

	1940		1950		1960	
	Number	Per- cent	Number	Per- cent	Number	Per- cent
Agriculture	13,917	34.9	9,081	30.0	2,509	10.6
Mining	2,142	5.4	1,830	6.0	1,493	6.4
Manufacturing	2,113	5.3	3,651	12.1	3,533	15.0
Major Water-using Industries	1,813	4.5	3,257	10.8	2,880	12.1
Primary Metals	459	1.1	695	2.3	497	2.1
Food and Kindred Products	269	.7	318	1.1	314	1.3
Chemical and Allied	20	---	21	---	15	---
Stone, Clay, and Glass	543	1.4	1,709	5.7	1,683	7.1
Other Nondurable Goods	522	1.3	514	1.7	371	1.6
All Others	300	.8	394	1.3	653	2.9
Basic Industries	18,172	45.6	14,562	48.1	7,535	32.0
Service Industries	12,911	32.3	14,332	47.4	14,435	61.2
Unemployed	8,820	22.1	1,370	4.5	1,612	6.8
Total Labor Force	39,903	100.0	30,264	100.0	23,582	100.0

Source: Bureau of the Census 6-8/

Agriculture

The study area has experienced some marked changes, not only in the loss of over 11,000 employed in agriculture between 1940 and 1960, as shown in table V-1, but also a shift in emphasis from crop production to livestock production. Table V-2 illustrates the shift, with less than 50 percent of total farm sales in 1944 resulting from livestock compared with 80 percent in 1959.

Table V-2

Agricultural Statistics for the Study Area
1944-1959

	<u>1944</u>	<u>1949</u>	<u>1954</u>	<u>1959</u>
Number of Farms	10,235	8,111	6,443	4,598
Acres of Cropland Harvested	489,906	306,124	235,327	153,103
Value* of all Crops Sold	8,516	3,808	2,150	2,399
Value* of all Livestock and Livestock Products Sold	7,733	7,221	6,456	10,086
Total Value* of all Farm Products Sold	16,249	11,029	8,606	12,485

*All values in 1,000's of 1954 dollars.

Source: Bureau of the Census 9-10/

Mining

Annual value of mineral production has averaged about \$50 million between 1953 and 1960, as shown in table V-3. Petroleum, natural gas, and natural gas liquids accounted for most of the value of mineral production. Other minerals extracted include clays, sand and gravel, coal, and stone.

Table V-3

Value* of Mineral Production in the Study Area
1953-1960

<u>Year</u>	<u>Value</u>	<u>Year</u>	<u>Value</u>
1953	54,841	1957	51,069
1954	57,591	1958	46,918
1955	55,807	1959	45,955
1956	50,486	1960	45,991

*All values in 1,000's of 1954 dollars.

Source: Bureau of Mines 11/

Manufacturing

Manufacturing employment has increased from 5 percent of the labor force in 1940 to 15 percent of the labor force in 1960. Table V-4 summarizes the number of study area establishments and the value added by manufacturing for the years 1939, 1947, 1954, and 1958. Glass manufacturing, oil refining, and zinc smelting lead all other industries in employment and income.

Table V-4

Manufacturing Activity in the Study Area 1939-1958

<u>Year</u>	<u>Number of Establishments</u>	<u>Value Added*</u>
1939	57	8,870
1947	53	19,057
1954	59	23,559
1958	61	18,197

*Values in 1,000's of 1954 dollars.

Source: Bureau of the Census 12/

Population

As shown in table V-5, the study area has undergone a general population loss since 1930. Although urban population has also shown a net loss since 1930, of 5,476, most of the loss was a result of outmigration of agricultural workers and their families.

Table V-5

Study Area Population--1920-1960

<u>Year</u>	<u>Total Population</u>	<u>Urban Population</u>
1920	132,347	26,779
1930	144,019	38,133
1940	126,146	35,555
1950	96,169	37,882
1960	77,665	32,657

Source: Bureau of the Census 13/

Future

The future growth of the study area will be influenced by the following factors:

1. The study area lies generally between Tulsa and Oklahoma City, the two largest metropolitan centers in Oklahoma. Growth of these population centers is expected to affect the growth of the study area.
2. Projections were made, assuming that the Deep Fork navigation project is constructed, thus providing cheap transportation from the study area to worldwide markets.
3. Navigation projects presently under construction on the Arkansas River, although not now being felt, will have the effect of increasing future growth and industrial development in the study area.

The above-named factors, coupled with anticipated increased national demands for manufactured products, are expected to result in a reversal of past trends and positive economic growth in the future. Labor force forecasts for 2025 appear in table V-6.

Table V-6

Study Area Employment--1960 and 2025--by Percentage of the Labor Force

	<u>1960</u>	<u>2025</u>
Agriculture	10.6	5.4
Mining	6.4	5.4
Manufacturing	15.0	19.3
Major Water-using Industries	12.1	15.1
Primary Metals	2.1	1.7
Food and Kindred Products	1.3	2.2
Chemical and Allied	---	.5
Stone, Clay, and Glass	7.1	9.3
Other Nondurable Goods	1.6	1.4
All Others	2.9	4.2
Basic Industries	32.0	30.1
Service Industries	61.2	64.9
Unemployed	6.8	5.0
Total Labor Force	100.0	100.0
Number of Workers (in 1,000's)	23.6	37.0

Population

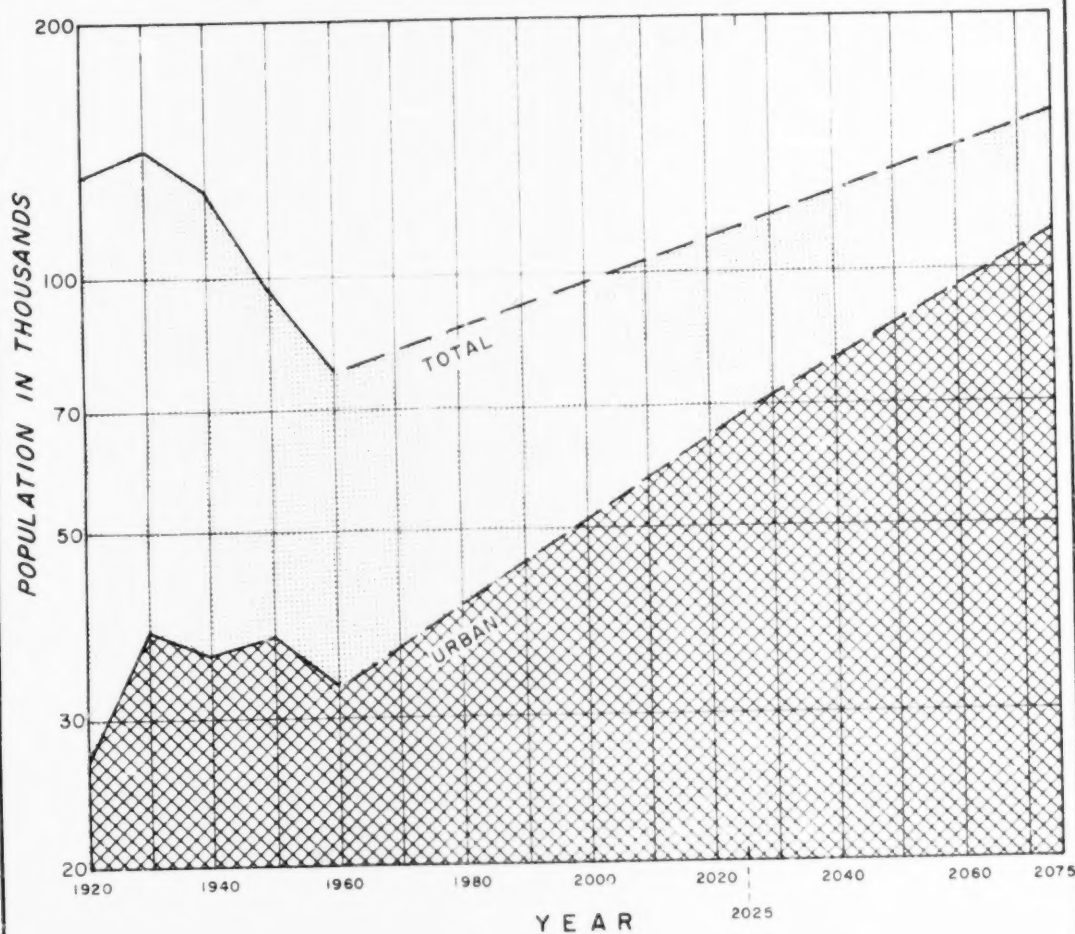
Total study area population is expected to reach 113,000 in 2025 and 155,000 in 2075, as shown in table V-7 and figure V-1. Most of this growth is expected in the urban component of the population.

Table V-7

Population for the Study Area--1960, 2025, and 2075

<u>Year</u>	<u>Total</u>	<u>Urban</u>
1960	77,665	32,657
2025	113,000	68,000
2075	155,000	110,000

V-6



WATER RESOURCES STUDY
CENTRAL OKLAHOMA NAVIGATION PROJECT

POPULATION TRENDS AND PROJECTIONS

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE V-1

VI. WATER REQUIREMENTS

General

Municipal and industrial water use is affected by various factors in the economy, the salient features of which were presented in the preceding chapter (V). Those elements which have influenced water needs in the past serve as guides in projecting requirements for municipal, industrial, and water quality control purposes.

Municipal

Municipal water needs include residential, public, commercial, and those industrial requirements which are served by organized public water supply systems and are reflected in a per capita use figure. Included are distribution system losses, water use for backwashing filters, together with other treatment plant losses, and evaporation from receiving reservoirs.

Present Use

Current average water use for municipal water supply purposes, together with existing sources of supply, is shown in table VI-1.

Table VI-1

Present Municipal and Industrial Water Use
Deep Fork River Basin, Oklahoma

	<u>Average Annual Use (mgd)</u>			<u>Present Source</u>	<u>Firm Yield (mgd)</u>
	<u>Municipal</u>	<u>Industrial</u>	<u>Total</u>		
Stroud	0.20	*	0.20	Wells	0.39
Bristow	0.20	*	0.20	Wells	0.82
Okemah	0.35	*	0.35	Wells	1.00
Okmulgee	1.65	0.75	2.40	Lake Okmulgee	7.00
Henryetta	0.50	0.25	0.75	Lake Henryetta and Wolf Creek	3.00
All other (est.)	<u>0.50</u>	<u>*</u>	<u>0.50</u>	Wells	>0.50
	3.40	1.00	4.40		

*Not significant.

Source: Field survey by Public Health Service during April 1963.

Future Needs

Future municipal water need is estimated by multiplying anticipated maximum annual per capita use by the projected study area population expected to be served by public water supply systems. Maximum annual per capita municipal need (for 2025) is expected to be 150 gallons per capita day (gpcd). Estimated 2025 total need for municipal water supplies is 12,100 acre-feet annually (10.8 mgd) in Deep Fork River basin (see table VI-2).

Industrial

Industrial water requirements are those significant quantities of water required in the manufacture of goods and the processing of materials which are more appropriately measured in units other than a per capita use.

Present Use

Principal industrial water users presently located in the study area include a petroleum refinery and several glass products plants at Okmulgee, along with a smelter and a glass products manufacturer at Henryetta. Field investigation in the study area revealed that the major industrial water users in the study area obtain their water supply from municipal systems.

The approximate distribution of present industrial water use is shown in table VI-1.

Future Needs

Projections of total industrial water requirements are based upon the water requirements per worker and the number of workers projected for each of the major water-using industries. (See Chapter V.) The industrial water requirements summarized with other projected water requirements on table VI-2 have been adjusted to take into account regional differences in industrial practice and anticipated recirculation and reuse of water.

Water Quality Control Requirements

Under the provisions of the Federal Water Pollution Control Act, Public Law 84-660, as amended by Public Law 87-88, consideration must be given to the inclusion of storage for regulation of stream-flow to control water quality in any reservoir being planned by a Federal agency. Storage and release of this water are not to be provided as a substitute for adequate treatment of wastes at the source.

Table VI-2

Water Use, Future Requirements, and Existing and Proposed Sources of Supply
Deep Fork River Basin, Oklahoma

<u>Requirements</u>	<u>Quantity</u>		<u>Current Use (mgd)</u>	<u>Sources of Supply</u>	<u>Firm Yield</u>		<u>Drought Recurrence Interval (years)</u>
	<u>Acre-ft. Annually</u>	<u>Avg. mgd</u>			<u>Acre-ft. Annually</u>	<u>Avg. mgd</u>	
2025 Needs							
Municipal	12,100	10.8	3.4	Existing Sources Ground Water	2,200	2	50
Industrial	12,500	11.2	1.0	Lake Henryetta & Wolf Creek	3,400	3	50
Out-of-stream needs	24,600	22.0	4.4	Lake Okmulgee	7,800	7	50
				Deep Fork--downstream from Arcadia	11,200	10	50
					24,600	22	
Quality Control	41,000	36.8		Controlled flow downstream from Arcadia	41,400	37	50
2075 Needs							
Municipal and Industrial	33,500	30		Ground Water and Sources of Surface Water Supply other than Deep Fork	13,400	12	50
				Deep Fork downstream from Arcadia	22,300	20	50
					35,700	32	
Quality Control	41,000	36.8		Controlled flow in Deep Fork downstream from Arcadia*	41,400	37	50

* Flow regulation for navigation in the upper basin, together with expected discharges of adequately treated sewage and industrial wastes, will provide for municipal and industrial water supply needs in the study area.

Water Quality Control Analysis

Water quality analysis is based on broad parameters which are used to evaluate stream conditions. Dissolved solids (DS) is employed to characterize the effects of stable pollutants (those constituents which are not utilized or reduced by stream environment) such as chloride salts. Dissolved oxygen (DO) concentration is applied as a measure of unstable pollutants (those constituents which decay and act on, or are acted on by, the stream environment) as appraised by biochemical oxygen demand (BOD). Although not an important quality consideration in meeting out-of-stream water needs, dissolved oxygen is a significant factor in maintenance of an environment proper for propagation of fish and other aquatic life. However, maintenance of suitable DO levels for maintenance of the aquatic environment generally assures adequate water quality for out-of-stream users as measured by other parameters.

The navigation project area offers a large scale recreational potential. There are many wooded areas through the valley which afford attractive sites for recreational development. Indications are that pools formed by the locks and dams of the navigation project would satisfy a latent need, not only for day use by local residents, but also for use by visitors from distant points.

Expectations are that satisfactory water quality conditions will be achieved by the maintenance of: (1) dissolved solids, which characterize stable pollutants, below 500 mg/l along with other water supply considerations, 98 years of 100; and (2) provision of storage for streamflow regulation which will maintain DO concentration in the order of 4 mg/l or higher, except for 1 year of 20, where the dissolved oxygen will drop to a minimum of 3 mg/l at the point in the receiving waters where the maximum effect of pollution is felt.

The following will be required for estimating water quality control requirements:

1. Adequate treatment, i.e., removal of 90 percent of the organic substances exerting a BOD will be achieved. Effluent from this treatment will contain 30 mg/l ultimate BOD and 4 mg/l DO. Currently available means of providing this level of treatment at reasonable cost remove essentially no dissolved solids.
2. Treated wastes will be mixed uniformly in receiving waters.

3. Dissolved oxygen content will be maintained at 4 mg/l or more in the stream 95 percent of the time, and other chemical and physical characteristics will not exceed limits described in the Public Health Service Drinking Water Standards--1962 for treated water. Releases from storage will be used to preserve these conditions.
4. Releases from storage for water quality control by flow regulation and uncontrolled (natural) stream-flow will have a DO content of 85 percent saturation and a BOD of 1 mg/l. (Other characteristics of quality are described in Chapter III.)

Existing Conditions

All municipalities in the study area provide secondary treatment of wastes released to the Deep Fork River basin. There does not appear to be gross water quality degradation resulting from wastes produced within the study area. However, Oklahoma City's North Side sewage treatment plant discharges 7.5 mgd of secondary effluent to headwaters of Deep Fork River. Although this waste has received a high degree of treatment, stream quality is frequently grossly degraded with respect to DO content since the natural stream-flow often drops to zero. There is an existing need for flow regulation to preserve water quality in the headwaters.

Future Conditions

Preservation of water quality in the Deep Fork River basin hinges upon regulating flows in the headwaters reaches to accommodate expected releases of adequately treated wastes from the Oklahoma City area. The quantity of wastes which should be permitted to be discharged to the upper reaches of the basin will be a function of flow regulation available and the quality of effluent from the Oklahoma City area. Since existing and expected conditions are critical in the headwaters, preservation of quality in those reaches will permit downstream release of adequately treated wastes resulting from anticipated economic expansion and population growth without adversely degrading stream regimen.

Under the above assumed conditions, 22,300 acre-feet/year (20 mgd) can be released downstream from the proposed Arcadia Reservoir site (release of even highly treated wastes upstream from the reservoir should be precluded in order to protect the quality of the impounded waters). If treatment practices improve, greater quantities of treated waste can be discharged without impairing overall quality.

Flow regulation requirements for water quality control are summarized in table VI-2.

2075 Water Requirements

It is assumed that 2075 water requirements will be proportional to population. Based upon projected total study area population of 155,000 in the year 2075, and the water supply and quality preservation plan shown in table VI-2, anticipated total study area needs for municipal and industrial water supply are 33,500 acre-feet annually, while requirements for water quality control purposes are 41,000 acre-feet annually.

Plan to Preserve Stream Quality and Meet Municipal and Industrial Water Supply Needs--Deep Fork River Basin

Releases from the two reservoirs in the upper Deep Fork River basin (Arcadia and Wellston sites) will provide flow required for navigation. These releases will likewise provide streamflow regulation for control of water quality along the entire Deep Fork River navigation channel.

Expected discharge of adequately treated wastes from the Oklahoma City area will increase flows in Deep Fork above the minimum required for navigation. This excess flow, which will be of suitable quality for general municipal and industrial purposes, will be available for diversion from Deep Fork for those uses. Approximately 22,300 Acre-feet annually (20 mgd) will be available from Deep Fork to municipal and industrial water users in the Deep Fork River basin downstream from the Arcadia Reservoir. (Users upstream from Arcadia Reservoir are expected to be served by the Oklahoma City water supply and pollution control system described in the Public Health Service report entitled "Water Resources Study, Southeastern Oklahoma and Southwestern Arkansas," dated July 1962, which this report supplements.)

VII. BENEFITS OF WATER QUALITY CONTROL

Control of water quality by streamflow regulation, resulting from the releases from storage as part of the proposed navigation project, will contribute the following benefits to the middle and lower reaches of the Deep Fork River basin, a distance of 150 miles more or less.

1. Reduce the cost of obtaining municipal and industrial water supply. In the absence of satisfactory quality conditions in Deep Fork River, the stream would be unsuitable for use as a source of water supply; thus requiring development of more costly sources.
2. Enhance recreational opportunities along the main stem through the avoidance of nuisance conditions. As previously discussed, current releases of highly treated wastes from the Oklahoma City area frequently degrade stream quality in the headwaters.
3. Improve the habitat for fish and other aquatic biology by preservation of suitable water quality conditions in the presence of adequately treated waste releases.
4. Preserve the esthetics for enjoyment of flowing surface waters by precluding the sights, smells, and other effects accompanying stream quality degradation.

Maintaining the waters of Deep Fork River basin in satisfactory condition will affect populations and economies beyond the confines of the basin, and will add a water resource to the area as well as the Arkansas River basin. By precluding the damages to fish life and other aquatic biology and providing esthetically pleasing flowing water, a recreational resource is created which will be readily available to all the peoples of the Southwest including Oklahoma City and Tulsa. The area is expected to grow considerably, thus multiplying the need for water-associated recreation. Since the water quality control plan is based upon enhancing the waters of the basin for this widespread use, benefits of water quality control resulting from this project can be considered widespread.

Water Quality Control Evaluation

Senate Document No. 97 (87th Congress, 2d sess.) permits the following method of measuring benefits of storage in Federal reservoirs for water quality control purposes:

"In situations where no adequate means can be devised to evaluate directly the economic effects of water quality improvement, the cost of achieving the same results by the most likely alternative may be used as an approximation of value."

Alternatives Considered

Control of water quality by streamflow regulation, utilizing storage in the proposed projects will result in preservation of fish life and other aquatic biology and of the esthetics of enjoyment of flowing surface waters. As shown in table III-2, natural discharges of the main stem of Deep Fork River upstream from Eufaula Reservoir are quite limited in quantity and incapable of receiving any significant quantity of adequately treated wastes. Under existing conditions, considering the present and assumed future state of the waste treatment art, flow regulation as described in the previous chapter is required to avoid the damages which result from gross pollution due to overloading the stream self-purification capacity.

Alternatives to storage in the proposed multipurpose projects for water quality control by flow regulation, capable of providing comparable benefits in the absence of flow regulation, include importation of water from other basins or storage in single-purpose reservoirs at the two sites under consideration.

Investigation indicated that single-purpose storage is the most likely alternative to storage in multipurpose projects.

Evaluation of Needs to Preserve Water Quality

The annual flow requirement, shown in table VI-2, is based upon preserving water quality in Deep Fork in the presence of adequately treated waste releases of 22,300 acre-feet annually (20 mgd) in the upper reaches of the basin.

Cognizance should be taken of the effect of stream channel alterations required to permit navigation in the Deep Fork River basin. The natural purification characteristics are expected to be altered by transformation of the stream from a free-flowing stream to a series of slack water pools. Greater releases from storage are

needed than would be required to preserve water quality in the absence of navigation. However, value is not attributed to the additional flow regulation requirements.

Therefore, the cost of that storage required to provide flow regulation for preservation of water quality in the absence of navigation is ascribed as the minimum value of benefits resulting from avoidance of poor water quality conditions. Also value is ascribed only to those increments of flow in excess of expected streamflows unmodified by the provision of storage in the critical headwater reaches. Table VII-1 reveals the various orders of flow regulation releases required for preservation of satisfactory quality and conditions (95 percent of the time) in Deep Fork River with waste releases from the Oklahoma City area limited to 22,300 acre-feet annually in accordance with the water supply and water quality control plan presented in the preceding chapter.

Table VII-1

Annual Flow Regulation Releases Needed to Preserve
Stream Water Quality 95 Percent of the Time
Deep Fork River Basin Above Eufaula Reservoir, Oklahoma

	<u>Acre-feet</u> <u>Per Year</u>	<u>Avg. Flow</u> <u>(mgd)</u>
Situation #1--Streamflow modified by storage and channel altered for navigation	41,000	36.8
Situation #2--Natural streamflow	22,300	20

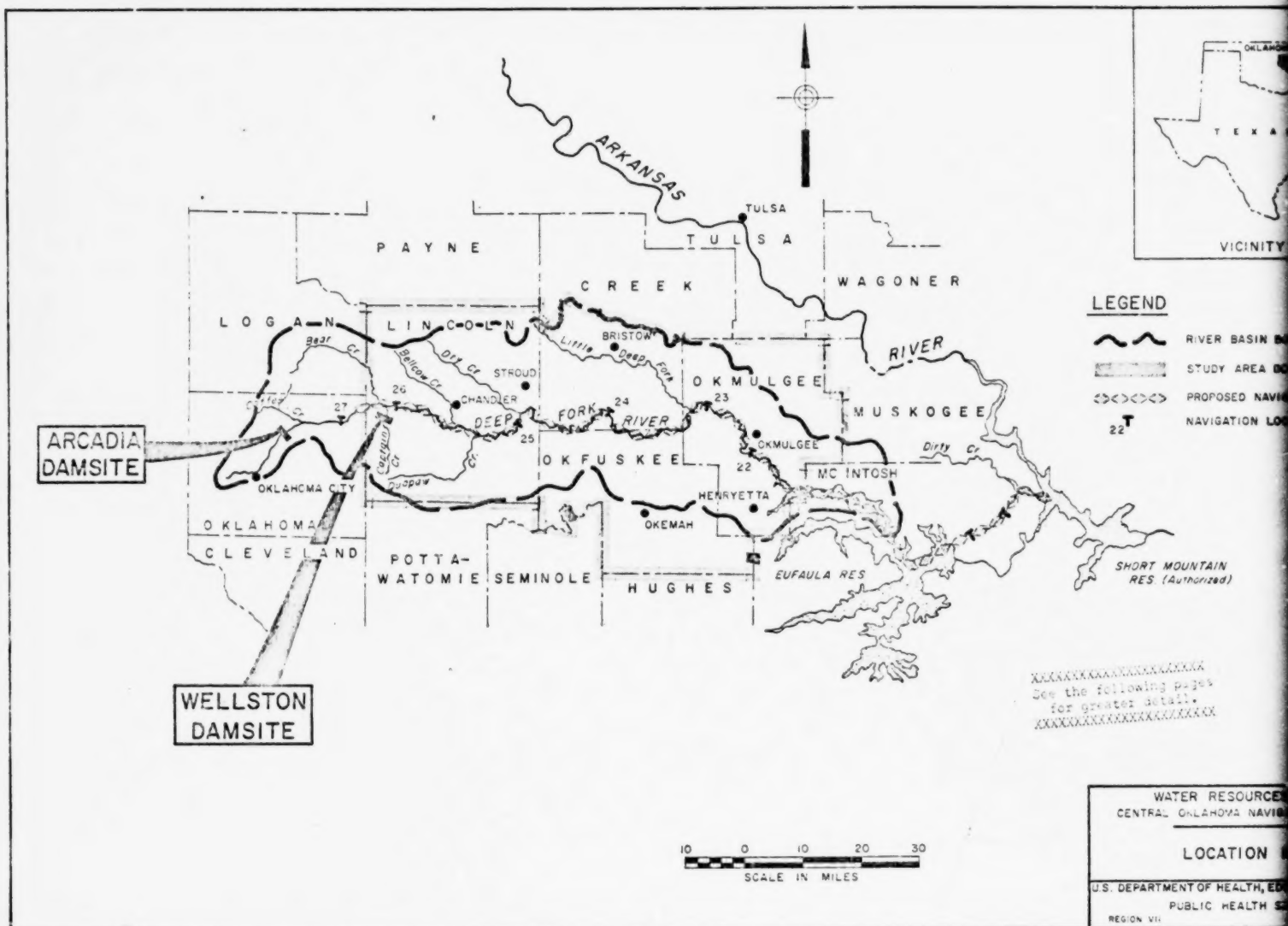
Note: All situations assume the release of 20 mgd of adequately treated Oklahoma City wastes.

According to the findings presented in table VII-1, the benefits of storage in the proposed multipurpose projects will have a minimum value equal to the cost of a single-purpose project capable of yielding 22,300 acre-feet annually 95 percent of the time. A single-purpose reservoir at the Arcadia site (which is ideally suited for this use in terms of location) would have an estimated first cost of \$10,867,000, including interest during the 2 years required to construct it. ^{14/}

Annual charges are estimated as follows:

Principal and interest--50 years @ 3%	\$422,400
Maintenance, operation, and major replacements	<u>63,500</u>
Total	\$485,900 ^{14/}

Based on the water supply and water quality control plan outlined in table VI-2, there does not appear to be a need for or value of storage for municipal and industrial water supply purposes, while the annual value of the benefits attributable to water quality control by flow regulation is estimated to be \$485,900.



VII-5

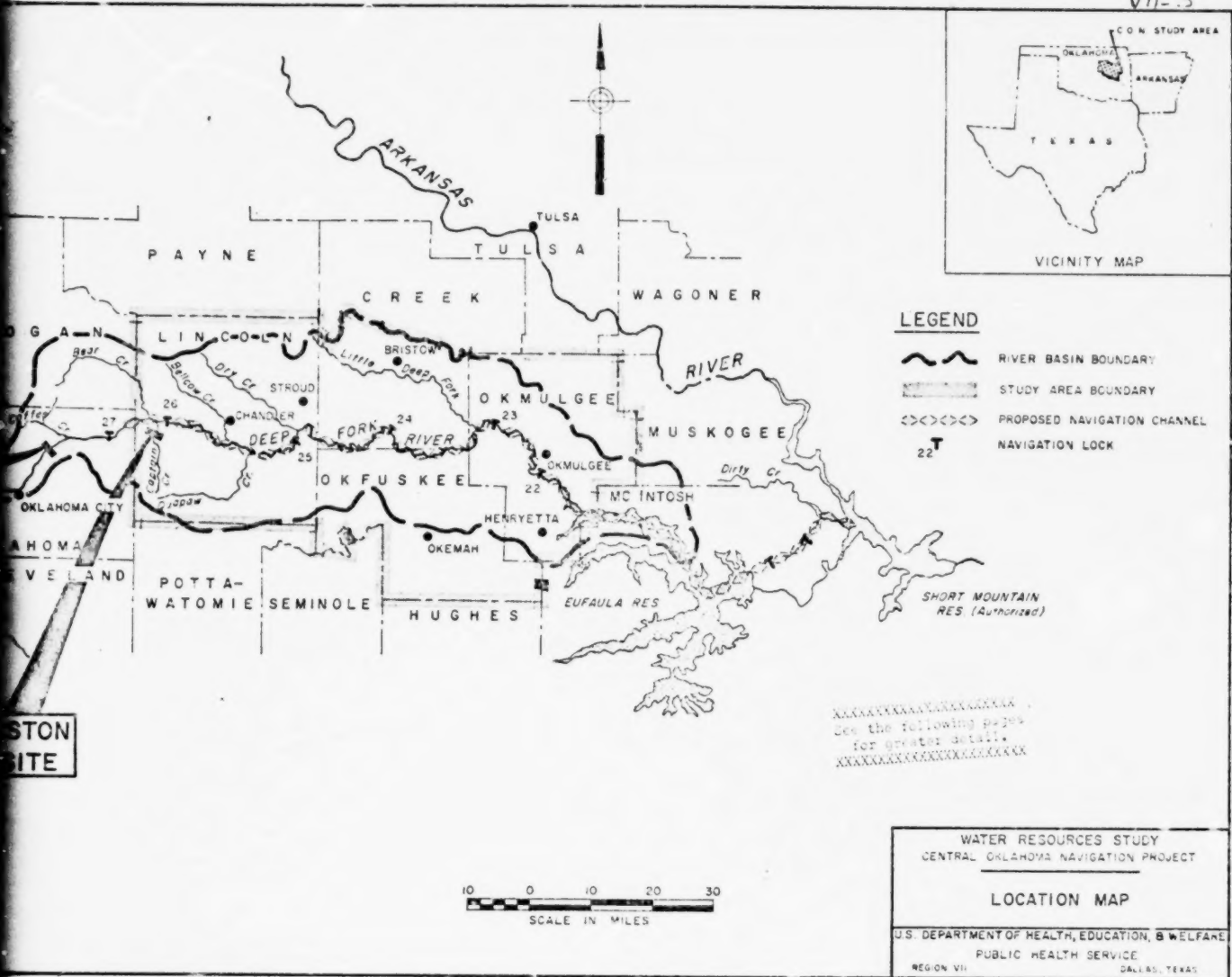
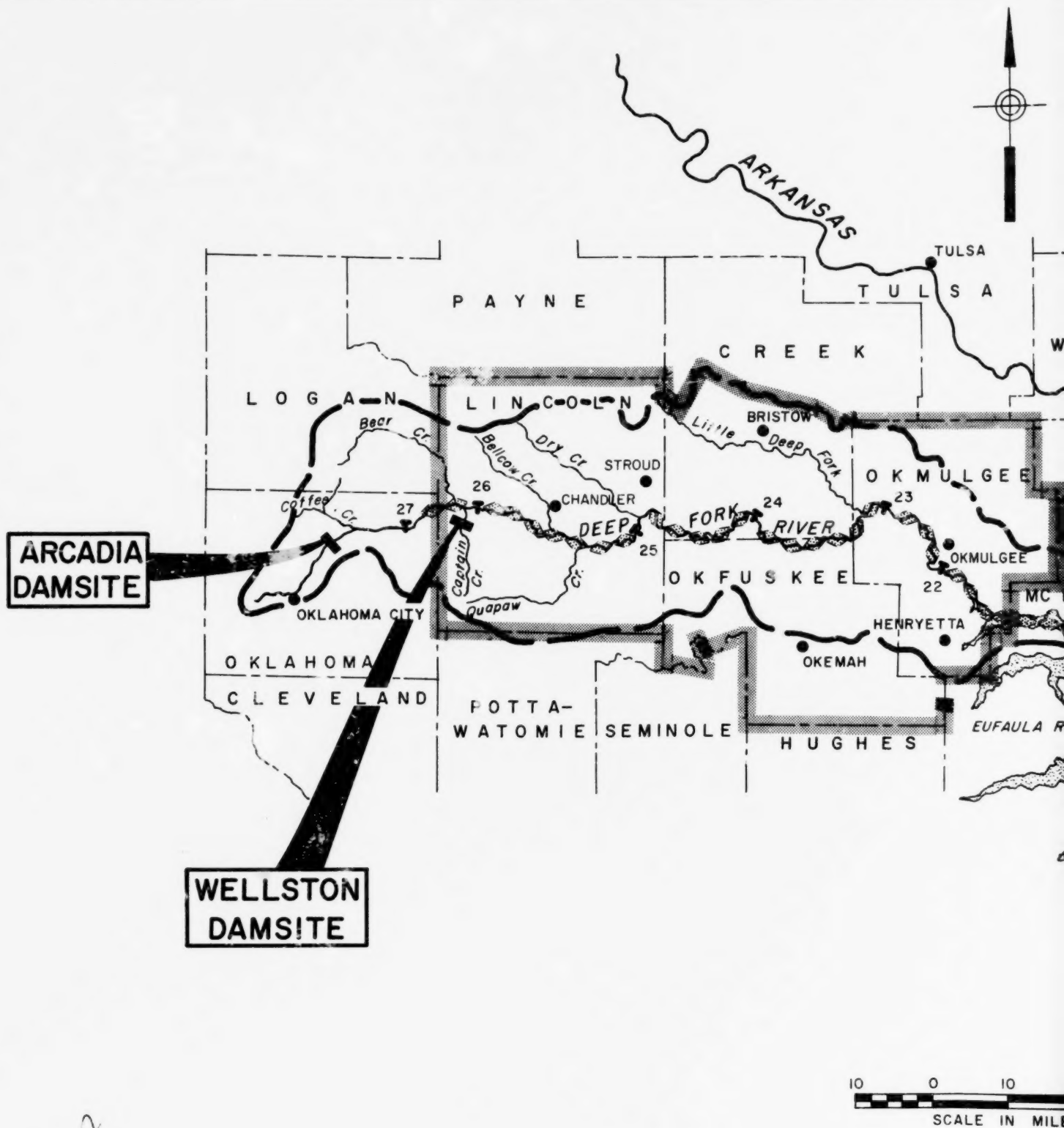
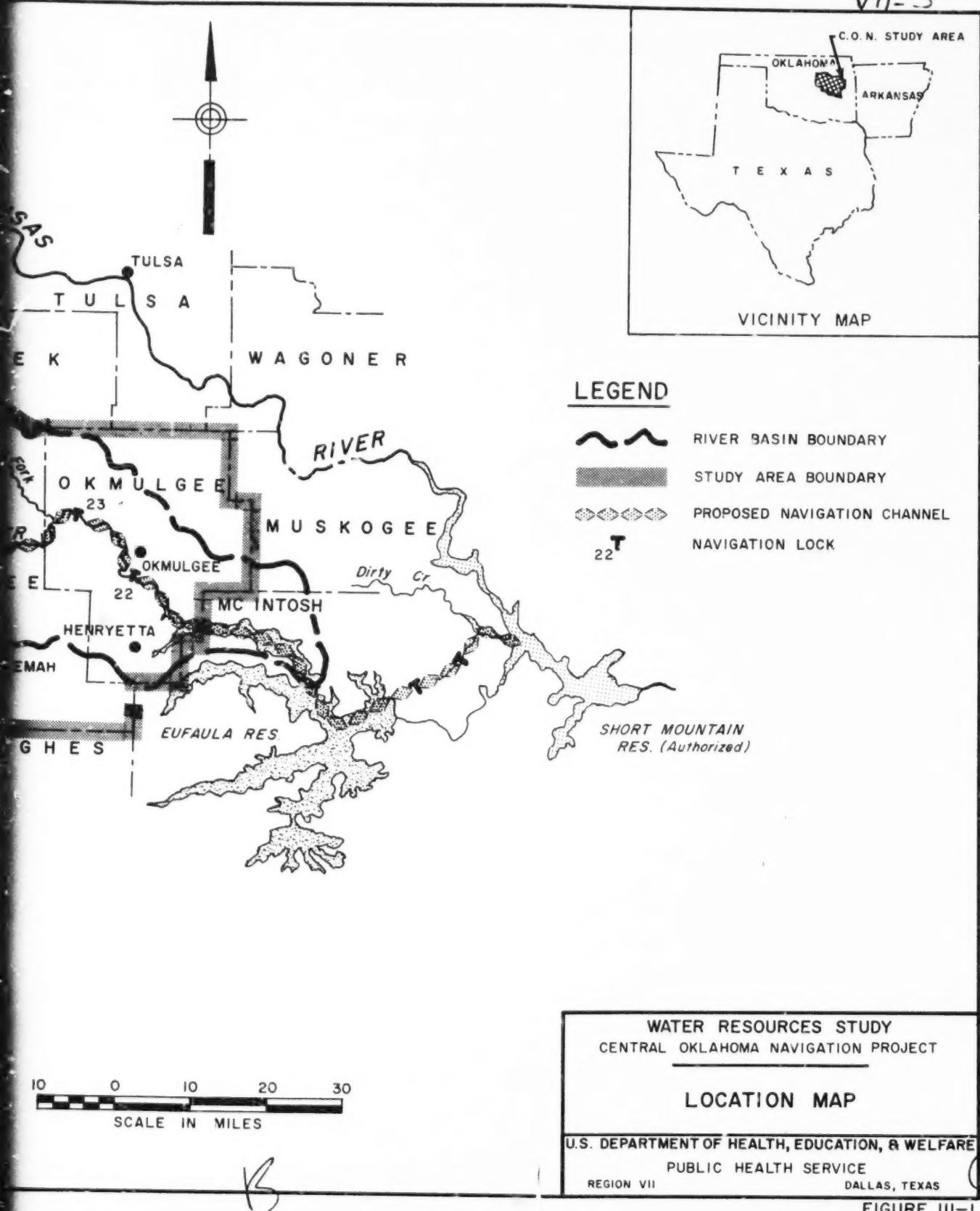


FIGURE III-1





VII-5



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